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Contagious and spontaneous yawning in autistic and typically developing children

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INTRODUCTION

1 Yawning is a widespread spontaneous behaviour observed not only in humans but also in several animal species (Baenninger, 1997; Walusinski & Deputte, 2004).

2 The role and function of the yawn vary according to the animal's place on the phylogenetic scale (Ficca & Salzarulo, 2002). In low evolutive species, yawning seems to be involved in homeostatic processes, whereas in high evolutive ones (mammals and primates) yawning could be linked to environmental needs (increased vigilance level; danger; hunting prey), or even communicative ones (sign of aggressiveness, hierarchic dominance, frustration, sexual excitement, means of synchronised activities within the group).

3 In humans, besides being a spontaneous event, yawning can be "contagious" (Provine, 1986), that is it can be elicited by viewing or hearing another person who yawns. Differently from spontaneous yawning, contagious yawning is observed only in humans (Provine, 1986), chimpanzees (Anderson, Myowa-Yamakoshi, & Matsuzawa,, 2004) and macaques (Paukner & Anderson, 2006).

4 During human development the "contagious" effect of yawning is found starting from four to five years of age and on (Anderson & Meno, 2003), differently from the precocious occurrence of spontaneous yawning observed from the second to third trimester of pregnancy in the foetus (de Vries, Visser, & Prechtl, 1982; Walusinski, Kurjak,

Andonotopo, & Azumendi,. 2005), and between 30 to 40 weeks of postconceptional age in preterm newborn infants (Giganti, Hayes, Akilesh, & Salzarulo, 2002; Giganti, Hayes, Cioni, & Salzarulo, 2007). The phase-shift between the emergence of spontaneous and "contagious" yawning could suggest separate processes underlying the two kinds of yawning, apparently similar, but probably different in their meaning.

5 Previous studies on anencephalous newborns able to yawn proposed that the brain's archaic structures were involved in spontaneous yawning occurrence (Price Heusner, 1949). More recently (Daquin, Micallef, & Blin, 2001), clinical and pharmacological studies indicated that several anatomical structures are implicated in the control of yawning, such as the hypothalamus (mainly the paraventricular nucleus), bulbus, pontic regions, with frontal region connections in primates and to the cervical medulla. Neuroimaging studies on contagious yawning found that viewing people yawn involves the activity of the posterior cingulate cortex (Platek, Mohamed, & Gallup, 2005) and superior temporal sulcus (Schürmann, Hesse, Stephan, Saarela, Zilles, Hari, & Fink, 2005): both are known to be associated with empathic processes of mental state attribution (Gallagher & Frith, 2003).

6 Taking into account the link between contagious yawning and the capacity for empathy, some authors (Platek, Critton, Myers, & Gallup, 2003; Schurmann et al., 2005; Senju, Maeda, Kikuchi, Hasegawa, Tojo, & Osanai, 2007) propose that the contagious effect of yawning could be impaired in "empathy disorders". In particular, Senju and colleagues (2007) report the absence of a contagious effect when autistic children view others yawn. The absence of contagious yawning in autistic children reported by Senju's study could be due to the their difficulty in establishing reciprocal gaze behaviour with human partners (Volkmar & Mayes, 1990). Indeed, autistic children look at others less frequently (Swettenham, Baron-Cohen, Charman, Cox, Baird, & Drew, 1998) and show deviant use of reciprocal gaze (Willemsen-Swinkels, Buitelaar, Weijnen, & van Engeland, 1998).

7 Furthermore, the presence of a contagious effect of yawning in autistic children could depend on their degree of functioning and low-functioning autistic children could show a greater impairment in yawning contagiousness with respect to high-functioning autistic children.

8 The aim of this study was to evaluate the contagious effect of yawning in autistic children with different degrees of functioning (high vs low functioning) and in typically developing children using two different modalities: the viewing and hearing of another person yawning. Furthermore, in order to avoid a bias arising from possible differences among groups in spontaneous yawning production, the frequency and the daily distribution of spontaneous yawning were evaluated and compared among three groups.

MATERIAL AND METHODS

Participants

9 Three groups of subjects were selected for this study: 7 high-functioning autistic children (HFA; 5 males and 2 female; mean age: 12.2 years (range 10-15 years)); 10 low-functioning autistic children (LFA.; 6 males and 4 females; mean age: 12.2 (range 10-15 years)) and 10 typically developing children (TD; 5 males and 5 females; mean age: 12 years (range 11-12 years)).

10 The children with Autistic Spectrum Disorder (ASD) were recruited at two institutes of diagnosis and intervention for autistic children in Florence (A.I.A.B.A (Associazione Italiana Aiuto Bambini Autistici) and C.T.E (Centro Terapeutico Educazionale). The diagnosis of ASD was performed by neuro- psychiatricians of the institutes according to DSM-IV (American Psychiatric Association, 1994) criteria. Degree of functioning (high vs low functioning) of autistic children was assessed by means of CARS (Childhood Autism Rating Scale) with the cut-off point set at 37. In both groups of autistic subjects, WISC-III was administrated to measure IQ. Characteristics of high and low functioning autistic children are listed in table 1.

11 The research project was approved by ethical committee and informed consent was obtained from parents of the three groups of children.

Subjects	Degree of functioning (H= high; L= low)	Age	Gender	Verbal IQ	Performance IQ	Full IQ	CARS
1	H	12	M	68	97	83	36
2	H	13	F	78	97	88	33
3	H	12	M	80	96	88	34
4	H	15	M	88	96	92	32
5	H	13	M	70	91	81	30
6	H	12	M	83	96	90	33
7	H	11	F	72	93	83	35
8	L	12	M	68	83	76	48
9	L	13	M	62	72	67	45
10	L	13	F	71	80	75	51
11	L	11	F	60	69	64	42
12	L	15	M	55	67	61	49
13	L	14	M	67	89	78	44
14	L	15	F	67	88	78	38
15	L	11	M	60	77	69	39
16	L	12	F	64	89	74	45
17	L	13	M	63	89	73	41

Table 1. Characteristic of autistic children. M= male; F= female; IQ = Intelligence Quotient score; CARS= Chlidhood Autism Rating Scale score.

Stimuli and procedure

12 The study was performed in two steps.

13 In the first step parents of the three groups of children were asked to count during a week-end spontaneous yawning of their children. Parents were instructed to record yawning occurrence during the morning (8:00-13:00), during the afternoon (13:00-19:00) and during the evening (19:00-23:00).

14 In the second step, all subjects underwent, in two different experimental sessions, to two stimuli conditions (one for each session) coupled with the respective control conditions.

15 The stimuli and control conditions consisted of video clips of young adults performing respectively yawns and smiles. In particular, in the stimuli conditions subjects observed twenty video clips of yawning faces (5 s each; 10 males, 10 females) and heard twenty video clips of yawning sounds (5 s each; 10 males, 10 females). The control conditions consisted of observing twenty video clips of smiling faces (5 s each;10 males, 10 females) and hearing twenty video clips of laughter sounds (5 s each; 10 males, 10 females). Stimuli were presented in a random order, with 5 s inter-stimulus interval between stimuli. Stimuli and control conditions were balanced for presentation order with a week interval between each experimental session.

16 Stimuli sequences were presented on the LCD monitor of a laptop computer and the faces of participants were recorded by means of web cam placed on the monitor.

17 All subjects viewed the movies in a silent and quiet room and were asked to indicate the gender of faces during the observation of yawns and smiles and to guess the gender of persons yawning and laughing during the listening to of yawning and laughter sounds. The experimental sessions were performed in the morning between 9:00 and 12:00. The videos were scored off-line and the coders were blind to the stimulus the children were watching or hearing. The number of yawns during each stimuli and control conditions was calculated. Two independent coders analysed the data-set and the agreement was (k=0.87).

Data analysis

18 Differences among the three groups of daily yawn distribution were evaluated throughout ANOVA for repeated measures with “group” as the between factor and “period of day” (morning, afternoon, evening) as the within factor and “number of yawns” as dependent variable.

19 Differences among the three groups of yawn production during each stimuli and control condition were evaluated by the Mann-Whitney test.

20 The contagious effect of yawning within each group was evaluated comparing the number of yawns during the stimuli conditions (viewing and hearing others yawn) with the number of yawns during the respective control condition (viewing and hearing others smiling/laughing) throughout Wilcoxon test.

21 Statistical significance was set at $p \leq .05$.

RESULTS

Spontaneous yawning

22 No differences between three groups of total daily yawns were found (mean±standard deviation for each group is: TD 9.3±2.9; HFA 8.5±2.3; LFA 8.1±1.9; F=321.8; n.s.).

23 The number of yawns was significantly modified across the day (F= 64.7; p= .01) without significant differences among the three groups (F=.37; n.s). Indeed, in all subjects the number of yawns was high during the morning, reduced during the afternoon and increased during the evening (Fig 1).

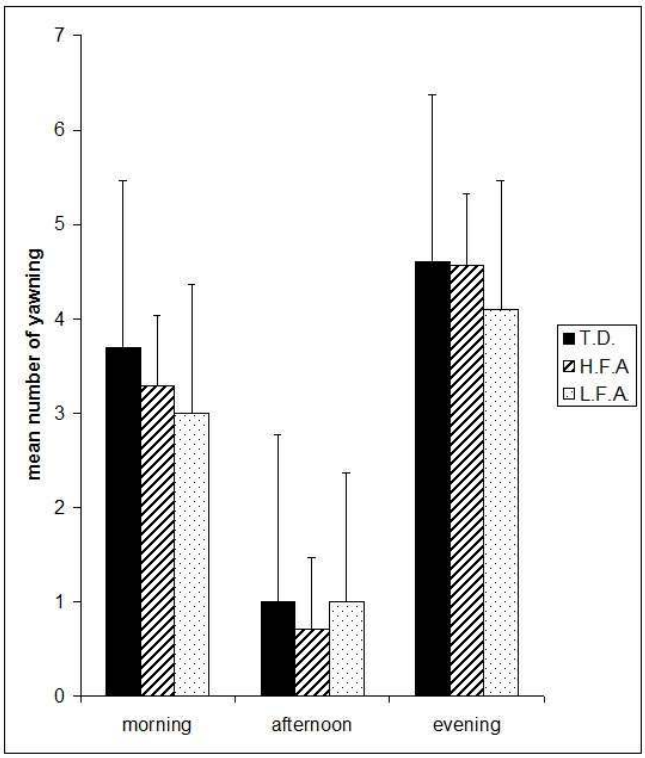


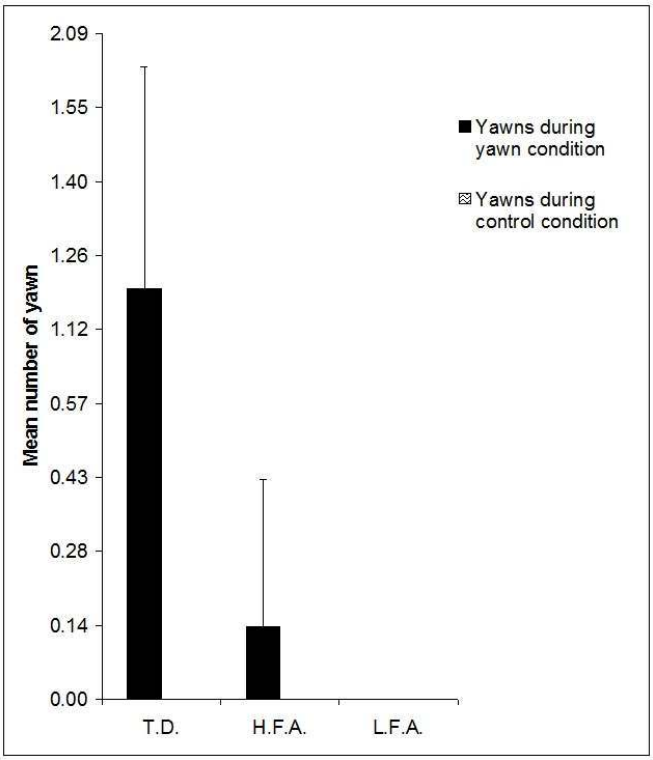
Figure 1. Daily distribution of yawning. T.D. = typically developing children; H.F.A.= high functioning autistic children; L.H.A= low functioning autistic children

Contagious yawning

Watching others yawning

24 The observation of yawning faces induced more yawning in TD children compared both to HFA children (U=13.50; p=.02) and to LFA children (U=15; p=.02), whereas no differences between HFA and LFA were found (U=.30; n.s.). Indeed, only a HFA subject yawned watching other people yawn, whereas none of the LFA subjects did.

25 In this situation, the contagious effect of yawning was observed only in the TD children (Fig 2) (z=-2.4, p=.01). In HFA children no significant differences between the number of yawns during the observation of yawning faces (stimuli condition) and during smiling faces (control condition) were found (z=1; n.s.). Indeed, HFA children yawned only during the stimulus condition and the number of yawns was very low. Finally, LFA children did not yawn either during the stimulus condition or in control condition.



26 Figure 2. Number of yawns during yawn condition (viewing others yawn) and control condition (viewing others smiling) in T.D. = typically developing children; H.F.A.= high functioning autistic children; L.H.A= low functioning autistic children.

Hearing others yawning

27 Listening to yawning sounds elicited more yawning in TD children compared to both HFA children (U=13.50; p=.02) and to LFA children (U=15; p=.02), whereas none of the HFA children and LFA children yawned while hearing others yawning (Fig 3).

28 In this condition, only TD children were sensitive to the contagious effect of yawning (z=-2.41; p=.01), whereas none of the HFA children or LFA children yawned while hearing others yawn or laugh.

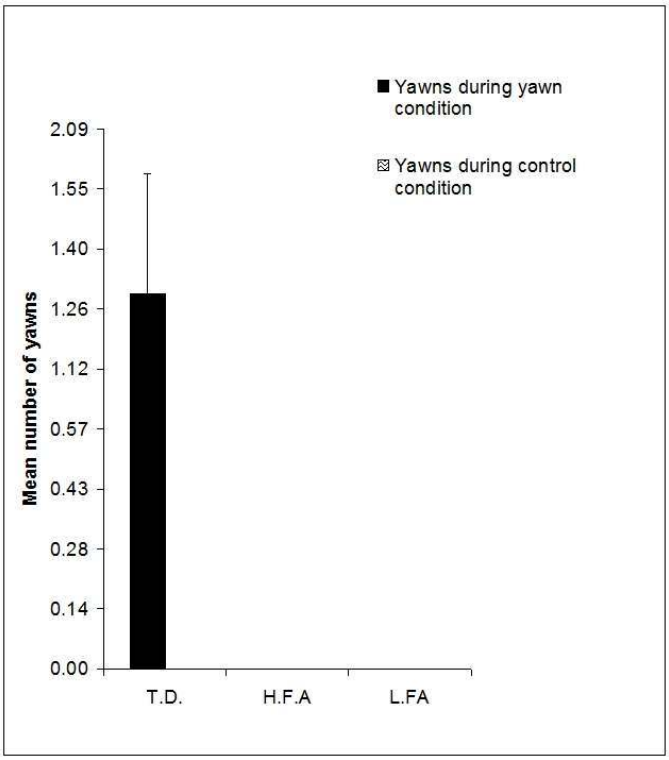


Figure 3. Number of yawns during yawn condition (listening to others yawning) and control condition (listening to others laughing) in T.D. = typically developing children; H.F.A.= high functioning autistic children; L.H.A= low functioning autistic children.

DISCUSSION

29 Our results showed that spontaneous yawning was not impaired in autistic children. In both HFA and LFA children the daily yawn frequency was similar to that observed in TD children. In addition, daily yawn distribution in autistic children corresponded closely to the daily distribution not only of TD children but also of adult people (Provine, Hamernik, & Curchack, 1987; Baenninger, Binkley, & Baenninger, 1996). Indeed the number of yawns was high during the morning, decreased in the afternoon and increased in the evening approaching onset of sleep.

30 Different from spontaneous yawning, contagious yawning seems to be impaired in autistic children. Indeed, typically developing children yawned more watching or hearing others yawn than both HFA children (only one of them yawned observing others yawn) and LFA children (none of them yawned either observing or hearing others yawn). This result does not depend either on the differences of spontaneous yawning among the three groups or the differences of spontaneous yawn distribution during the daytime.

31 Consistent with previous data (Senju et al., 2007), our results showed the absence of contagious yawning in autistic children when they view others yawning. The contagious effect of yawning during the listening to of others yawning was also impaired in these subjects. This result is contradictory to our hypothesis that autistic children's difficulty of establishing a reciprocal gaze behaviour with their caregivers and other people (Volkmar & Mayes, 1990) could affect the contagious effect during the observation, but not during the listening to of others yawns. Therefore, our data pointed out that a specific disorder

such as ASD can selectively affect some behaviours such as yawning. Indeed, whereas the spontaneous production of yawning in autistic children appeared to be preserved, yawning in response to the observation or to the listening to of others yawning was largely impaired. This result together with the phase-shift between the emergence of spontaneous and that of "contagious" yawning, contribute to bear out the hypothesis of separate processes underlying the two kinds of yawning.

32 The absence of contagious yawning in autistic children and the impaired capacity for empathy reported in these subjects (Baron-Cohen, Knickmeyer, & Belmonte, 2005) support the widespread proposal (Anderson et al., 2004; Platek et al., 2005; Schurmann et al., 2005) of a link between contagious yawning and social abilities such as self-awareness and mental state attribution that show an atypical development in ASD (Leslie & Frith 1988; Baron-Choen, Leslie, & Frith,1985). It is unlikely that the absence of contagious yawning in autistic children could be due to impairments of imitative abilities or of the mirror neuron systems involved in action and intention understanding found in these subjects (Dapretto, Davies, Pfeifer, Scott, Sigman, Bookheimer, & Iacoboni, 2006). In this regard, it is noteworthy to observe that autistic children are able to mimic behaviours such as smiles and laughter in our "control" conditions. Indeed, even if the evaluation of the contagious effect of laughing was not our main aim, we observed that in the control condition high functioning autistic children tend to smile more watching others smile than watching others yawn ($z= -1.84$; $p=.06$) and laughed more listening to others laugh than listening to others yawn ($z=-2.03$; $p= .04$).

33 These results could be interpreted also taking into account the proposal to consider empathy a "collection of partially dissociable neurocognitive systems" (Blair, 2005, pag. 698). In particular three different levels were described: cognitive, motor and emotional empathy. Cognitive empathy refers to the ability to represent the mental state of others; motor empathy refers to the capacity to automatically mirror vocalizations, facial expressions and motor behaviours of another person and finally emotional empathy refers to the recognition and response to emotional expressions of other people, as well as various other emotional stimuli. Autistic subjects were found to be impaired with respect to both cognitive and motor empathy, whereas they seemed to show less difficulties with respect to emotional empathy (see Blair, 2005 for a review). The sensitivity to the contagiousness of yawning could reflect cognitive empathy and the absence of contagious yawning in our sample could confirm the impairment in cognitive empathy previously reported in autistic subjects. Moreover, the response to others laughing and smiling (probably reflecting emotional empathy) observed in high functioning autistic children, but not in low functioning ones, not only supports data about the presence of emotional empathy in autistic subjects, but also suggests different levels of empathic capacities according to the degree of functioning.

34 Finally, the contagious effect of yawning was confirmed in typically developing children in agreement with previous results showing this effect in younger children (Anderson & Meno, 2003). Furthermore, this is the first study to show the contagious effect of yawning in children listening to others yawn. It is interesting to observe that the percentage of contagious yawning found in typically developing children was higher than the percentage reported by Provine (2005) in the young adult. Indeed, whereas in our study 70 % of children yawned watching others yawn, only 55% of young adults yawned (Provine, 2005) while observing yawns. Maybe children are less subject to the social inhibition of yawning than young adults. Indeed, Provine (2005, p.539) reported that

"even highly motivated and prolific yawners [...] stopped yawning when placed before the camera" of a national television.

35 In conclusion, our study showed that ASD can selectively affect some behaviours. In autistic children the response to yawning, both viewed and listened to, is largely impaired, whereas the spontaneous production and daily distribution of yawns is not. These results support the hypothesis of a link between contagious yawning and social abilities and the existence of different processes underlying spontaneous and contagious yawning.

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ABSTRACTS

Previous studies have reported the absence of a contagious effect when autistic children view another's yawning. This result could be due to the difficulty of autistic children in establishing reciprocal gaze behaviour with human partners. Furthermore, the presence of a contagious effect in autistic children could change according their degree of functioning. We evaluated the contagious effect of yawning in both autistic children with different degrees of functioning and

in typically developing children exposed to the viewing and hearing of others yawn. Furthermore the frequency and the daily distribution of spontaneous yawning were evaluated and compared among three groups. Autism Spectrum Disorder can selectively affect some behaviour. In autistic children the contagious effect of yawning is largely impaired, whereas the spontaneous production and daily distribution are not. These results support the hypothesis of a link between contagious yawning and social abilities and the existence of different processes underlying spontaneous and contagious yawning.

L'absence de sensibilité à la contagion du bâillement des enfants autistes a déjà été décrite dans la littérature psychologique. La difficulté de ces enfants à produire un contact visuel dyadique pourrait en être la cause. En fait, il est possible que cette situation diffère suivant le niveau d'atteinte autistique.En projetant une vidéo de bâillements et faisant écouter un enregistrement sonore de bâillements, nous avons évalué l'effet contagieux du bâillement chez des enfants autistes, dont l'atteinte était plus ou moins profonde, en les comparant à des enfants non autistes.Nous avons également évalué la fréquence et la distribution journalière de bâillements spontanés et comparé entre elles les données recueillies dans trois groupes différents. Chez les enfants autistes, l'effet contagieux du bâillement est profondément altéré, alors que la fréquence des bâillements spontanés et leur distribution journalière ne sont pas modifiées. Ces résultats tendent à confirmer l'hypothèse d'un lien entre la contagion du bâillement et l'aptitude élaborer un lien social apparenté à l'empathie. Il en résulte qu'il est probable que les bâillements spontanés et les bâillements contagieux font intervenir des processus neuropsychologiques différentes.

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Keywords: autism spectrum disorder, children, contagious yawning, spontaneous yawning

AUTHORS

FIORENZA GIGANTI

Department of Psychology, University of Florence, Italy fiorenza.giganti@unifi.it

MARIA ESPOSITO ZIELLO

Department of Psychology, University of Florence, Italy